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OBSERVATIONS ON THE FEEDING HABITS OF THE PURPLE-TIPPED SEA-URCHIN.

By H. N. Milligan.

Although the Purple-tipped Sea-Urchin (*Echinus miliaris*) is very abundant around our shores, and is doubtless often kept in aquaria, our knowledge of its feeding habits, as is so often the case with common sea-shore animals, is very meagre. With the exception of Eichelbaum's* investigations into the contents of the intestines of eleven examples of this Sea-Urchin, varying from 17 to 48 mm. in diameter,† from the North Sea, only minor notes on the subject are to be found scattered sparsely through the literature relating to echinoderms. It therefore seemed advisable to record the new observations which are contained in the following paper. These observations are based on the detailed notes which have daily been made by me upon the behaviour of the Purple-tipped Sea-Urchins (some sixty in number) which have lived during the last three years in the marine aquaria at the Horniman Museum. The following are the subjects which will be discussed: (1) Animal matter as food; (2) vegetable matter as food; (3) inorganic matter as food; (4) the search for food; (5) the positions and postures adopted in feeding; and (6) the time spent in feeding.

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* E. Eichelbaum, "Über Nahrung und Ernährungsorgane von Echinodermen," 'Wissench. Meeresuntersuch. v. d. Kommission z. Wissen. Unters. d. Deutsch. Meere in Kiel,' N. F., Band 11, Kiel, 1910, pp. 189–275.

† Eichelbaum's measurements, and also those given by myself, are those of the long diameters of the tests, excluding the spines.

1. Animal Matter as Food.

Chordata.—Eichelbaum found remains of the ascidian *Cynthia* in one, and probably in two, of the eleven Sea-Urchins which he examined.

A Sea-Urchin, 23 mm. in diameter, was observed by me to devour part of an *Ascidia sp.* of 30 mm. in length. The species of fishes which have died in the aquaria and have been wholly or partially devoured by the Sea-Urchins are the Striped Wrasse (*Labrus mixtus*), Common Goby (*Gobius paganellus*), Gattorugine Blenny (*Blennius gattorugine*), and Plaice (*Pleuronectes platessa*). The fins, flesh, and viscera of the fishes have been eaten, but the bones have usually been neglected. A Sea-Urchin, however, which was given a small mass of bone from the skull of a Gattorugine Blenny, the flesh of which had been scraped away by other echinoids, ate a portion of it. In has already been recorded in 'The Zoologist' that four Sea-Urchins were seen to work with their teeth upon two groups of eggs laid by a Sea-Bullhead (*Cottus bubalis*), though with what result it was difficult to see.* Raw beef is eaten with avidity. The Purple-tipped Sea-Urchin would probably eat any dead marine chordate, or even any dying chordate which it could attack with success.

If the Sea-Urchin can once obtain a grasp of a small dying fish, it holds the fish tenaciously, as is exemplified by the following incident.† A Striped Wrasse of 40 mm. in length, which was thought to be dead, was removed from an aquarium in order that it might be used as food for the Sea-Urchins. When, however, the tail of the fish was thrust beneath the body of one of the Sea-Urchins, 38 mm. in diameter, which was clinging to the vertical side of the aquarium, the fish suddenly began to

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* H. N. Milligan, "Notes on the Eggs and Larvæ of a Sea-Bullhead (*Cottus bubalis*)," 'Zoologist,' vol. xix, 4th ser., 1915, pp. 292–6.

† I have not been able to find any previous record of this Sea-Urchin deliberately holding prey with its spines, but H. Eisig ("Biologische Studien angestellt in der Zoologischen Station in Neapel," 'Kosmos,' vol. xiii, 1883, p. 128), mentions that an *Echinus* (*Strongylocentrotus*) *lividus* held a worm with the points of its spines.

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struggle. The Sea-Urchin held it tightly by pressing a number of spines not only around but also upon the body of the fish, those spines which were pressed on the prey being used with such effect that they made deep indentations in its body. The Sea-Urchin now raised one part of its body from the side of the tank, and with spines and tube-feet gradually urged its prey towards the mouth, the fish, in spite of several efforts, being unable to get free. As soon as the prey had been brought into such a position beneath the mouth that the teeth could conveniently work upon it, the Sea-Urchin attached a number of tube-feet to, and also pressed spines upon, the side of the tank in such a way that the victim was imprisoned as in a cage. The Sea-Urchin remained for several hours upon the Wrasse, of which it ate about a third part, afterwards allowing the remainder to fall to the bottom of the aquarium.

Arthropoda.—Eichelbaum found remains of crustaceans in each of his eleven examples. These remains consisted of legs, antennæ, etc., fragments of small crabs, and also copepods and a questionable *Gammarus.*

One of the Sea-Urchins studied by me climbed on to a living Top (*Trochus zizyphinus*), which bore several living Acorn-Barnacles (*Balanus balanoides*), broke up the shells, and then ate the soft parts of the cirripedes. A large dead Common Hermit-Crab (*Eupagurus bernhardus*), which was placed in an aquarium containing twelve Sea-Urchins, was soon attacked by four of the echinoids; they ate the whole of the Hermit-Crab's abdomen (including the limbs), three of the walking legs (the great claws not being touched), most of the carapace and contents of the thorax, and the antennæ of one side. A large male Long-legged Spider-Crab (*Stenorhynchus phalangium*) died during the night, and before the morning was partly eaten by a large Sea-Urchin, which completely devoured the small abdomen of the crustacean, and scraped away the surface layer of a considerable area of the under surface of the thorax. Two of the great claws of a Common Spider-Crab (*Hyas araneus*) were given to two large Sea-Urchins, and in both cases they were almost wholly eaten. Six walking-legs of the Common Spider-Crab and two of the walking-legs of the Shore-Crab (*Carcinus mænas*) were on one occasion distributed amongst eight large Sea-Urchins, and were wholly or partially eaten. The long halves of four of the legs of *Hyas*, together with their soft contents, were eaten, and the other halves then abandoned. It may also be remarked that on three other occasions when Sea-Urchins ate halves of limbs, they afterwards placed the uneaten halves on their upper surfaces amongst the other foreign objects with which the Purple-tipped Sea-Urchins so frequently load themselves. A carapace, 48 mm. in length, of a dead Common Spider-Crab was given to a Sea-Urchin of 38 mm., and was nibbled around its edge.

The avidity with which the Purple-tipped Sea-Urchin will feed upon an exoskeleton which has been moulted by a shrimp or prawn is very remarkable; indeed, it has now become my practice to give all such cast exoskeletons to the Sea-Urchins as part of their food, and they are very seldom refused. Out of thirty-three consecutive exoskeletons of shrimps, varying from 45 to 75 mm. in length (excluding the antennæ), all except two were at once taken by the Sea-Urchins to which they were presented, and the two exceptions were afterwards eaten by other Sea-Urchins. It should be understood that the exoskeletons are not eaten only by starving Sea-Urchins; they are eagerly taken by well-fed individuals which immediately before have been devouring seaweed. A Sea-Urchin of 42 mm., abundantly supplied with seaweed, ate each of the fifteen successive exoskeletons which were given to it in the course of thirty-one days.

The worm-shaped fæces of the Shore-Crab, Common Spider-Crab, Common Hermit-Crab, and Sea-Bullhead are eaten by a Sea-Urchin whenever these are offered to it. The echinoids would probably eat the fæces of almost any other marine animal. A Sea-Urchin detected the presence of three fæces (of 15, 21, and 25 mm. in length) of a Shore-Crab when they were placed three-quarters of an inch away; and within a few minutes the animal approached, and ate them.

It has already been mentioned (p. 83) that the tube-feet and spines may be used to imprison a dying Wrasse, and it may here be added that these appendages are of great use in holding food when the Sea-Urchin is clinging to a vertical surface. When, for example, a Sea-Urchin, attached to the glass front of the aquarium, is given the exoskeleton of a shrimp, it may dismember the exoskeleton in the course of the meal, but will retain such a hold of the separate parts that few, or in some cases none, of them are allowed to fall to the bottom until the Sea-Urchin has finished. A Sea-Urchin of 32 mm. to which one of the slender antennæ, 5¼ inches long, of a Spinous Galathea (*Galathea strigosa*) had been given, at once held the antenna by quickly crossing those spines bordering the antenna as it lay on the upper surface of the echinoid. The antenna was eaten partly by this Sea-Urchin and partly by another one, which rapidly approached from a distance of four inches in order to join in the meal.

Mollusca.—The remains of molluscs were found by Eichelbaum in seven Sea-Urchins. They consisted of fragments of lamellibranchs, and of lamellibranch and pteropod shells (including *Cardium* and *Limacina*).

All the Sea-Urchins studied by me have readily eaten the soft parts of dead and gaping mussels. They have also attacked, killed, and partially or wholly eaten living gastropods in large numbers. For example, about sixty individuals of the gastropod known as *Rissoa membranacea*, with an average length of shell of 5 mm., were placed in the aquarium containing the twelve Sea-Urchins already referred to, on September 16th; about fifty specimens of *Rissoa* were added in October; about fifty others in December; and several others were added on various dates; nearly two hundred in all were placed in the tank in the course of four months. Many of the *Rissoæ* were killed and eaten by several Cushion-Stars (*Asterina gibbosa*) which lived in the same tank, but about an equal number of them were eaten by the Sea-Urchins, and by the end of the following January there were only about a dozen left. A Sea-Urchin has been seen on the glass front of the aquarium holding as many as four living *Rissoæ* at once; one of the molluscs, at the time the observation was made, being actually held to, and partly in, the mouth, whilst the others were imprisoned between the glass and the spines of the Sea-Urchin.

A Sea-Urchin will "sit" persistently upon the inverted shell of a living or dead gastropod until sooner or later it is able to extract the animal. A Sea-Urchin of 21 mm., which was observed to be sitting on an inverted Top (*Trochus zizy-*

phinus), was suddenly lifted in order that it might be ascertained what the echinoderm was doing; and it was then found that the latter was so firmly affixed by spines, tube-feet (and pedicellariæ?), that the Top, which was dead, was dragged from its shell. The individuals of the Dog-Whelk (*Nassa reticulata*), some sixty in number, and of the Periwinkle (*Littorina littorea*), some fifteen in number, which have from time to time been placed in the tank containing the twelve Sea-Urchins, have been much persecuted by the echinoids. The operculum of one such Periwinkle, which was rescued from a Sea-Urchin, had been nibbled around its edge, no doubt during an attempt of the Sea-Urchin to reach the soft body of the mollusc. In the case of a gastropod, which of course is able to withdraw into its shell for some distance, the extensile mouth-membrane and the protrusible teeth and lip of the Sea-Urchin must be of great use; but it is impossible to observe directly what happens, owing to the close contact between the lower surface of the Sea-Urchin and the mouth of the shell. A Sea-Urchin may be seen from time to time to climb slowly up the glass, dragging with it, and eating, the body (without the shell) of a Periwinkle or a Dog-Whelk.

The Sea-Urchins have also eaten the eggs laid by Dog-Whelks. On two occasions they have been seen to devour the byssal threads abandoned by an Edible Mussel (*Mytilus edulis*).

A Sea-Urchin will sometimes place itself in such a position that it can firmly hold a living mollusc, and will then repeatedly scrape the surface of the shell with its teeth, in some cases apparently in order to eat the hydroids, polyzoans, or seaweeds which grow upon the shell, and in other cases to eat the periostracum. This has been observed in the case of the Edible Mussel, Slipper Limpet (*Crepidula fornicata*), Dog-Whelk, Sting-Winkle (*Murex erinaceus*), and Dog-Winkle; and the rugosities of the shells of the Sting-Winkle and Dog-Whelk may be scraped in this way until they become worn down to the level of the rest of the shell (fig. 1, A). In doing this the Sea-Urchin may desire to reach and eat the shell, as well as to obtain the materials which invest it. Indeed, the Purple-tipped Sea-Urchin will eat comparatively large quantities of shell. The subject of shell-eating by this animal, which has received little or no attention, is one peculiarly deserving of study. An empty shell, if it is not thick and heavy, which lies in an aquarium containing a number of healthy Sea-Urchins, will probably be bitten sooner or later by the echinoids.

On August 8th an average-sized, old, and friable shell of a Whelk, to which were attached thirty-five empty shells of the Acorn-Barnacle, was put in the tank containing the twelve Sea-Urchins, whose diameters ranged from 10 to 27 mm. By August 20th eight of the barnacle shells had been gnawed away completely, together with part of the last whorl of the whelk shell (fig. 1, B). The Sea-Urchins apparently began to break away the shell of the Whelk at the place where a circular

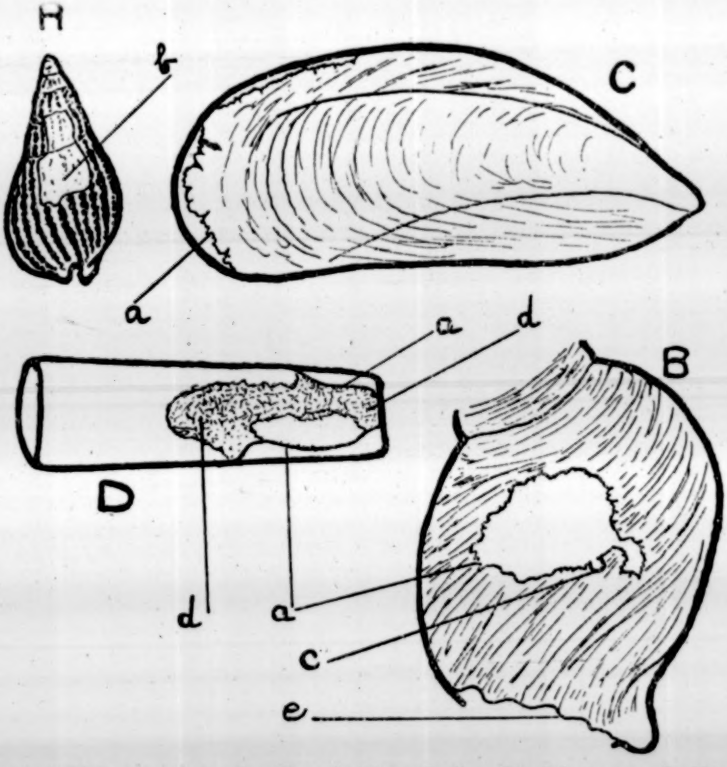

FIG. 1.—Objects eaten by Purple-tipped Sea-Urchins. A, shell of Dog-Whelk; B, last whorl of shell of Whelk; C, right valve of shell of Mussel; D, piece of chalk. In all cases the original size of the object is indicated by the thick black line, and the amount eaten is shown by the thin line, lettered, *a*, *a*, *a*; *b*, area of rugosities scraped away; *c*, boring made by carnivorous mollusc; *d*, impressions of teeth of Sea-Urchin; *e*, broken part of shell not eaten by Sea-Urchins. (All natural size.)

hole had been bored by a carnivorous gastropod during the lifetime of the Whelk (fig. 1, B, *c*). About half of a large whelk shell, which was broken up and thrown into the tank on August 2nd, was eaten by the Sea-Urchins by the 9th, certain of the harder parts of the shell, however, such as the columella and shell-siphon, being left uneaten until the present. A Sea-Urchin will seize a living Periwinkle, or an empty periwinkle shell, and hold it in such a way that the thin edge of the lip of the shell lies conveniently under the mouth of the Sea-Urchin, and the latter will then proceed to snap off tiny pieces along the lip. Two or three Periwinkles which had evidently been treated in this fashion were at one time to be seen crawling about the aquarium; but, of course, it is only in the rare case of a mollusc being seized when it is close to the glass that the process can actually be watched.

The shells of several living Edible Mussels have been damaged by the Sea-Urchins, and in all cases they were bitten at their hinder ends (fig. 1, c). On several occasions a Sea-Urchin has gnawed the valves of a Mussel in such a way that a gap has been made between them; and through this gap the thick edge of the retracted mantle, where it forms the boundaries of the inhalent and exhalent apertures, could be seen. In at least two cases a large Common Starfish (*Asterias rubens*), attracted by the exposed soft parts of the Mussel, has attacked and opened the mollusc. This matter may deserve further investigation from the bionomic and economic points of view, as it is known that a Starfish can throw its stomach through a comparatively narrow aperture.*

Echinodermata.—Eichelbaum found the remains of echinoderms in ten examples. These remains were those of asteroids, ophiuroids, and echinoids, and they included shell fragments, spines, and pedicellariæ.

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* M. Hesse ("Note sur les Motifs qui determinent les Oursins a se creuser dans les Rochers," 'Ann. d. Sc. Natur., T. vii, series 5, 1867, p. 259) mentions that *Echinus miliaris* will bore into oyster shells. K. Möbius ("Über die Thiere der Schleswig-Holsteinschen Austernbänke," 'Sitzungsb. König. Preuss. Akad. Wissen. Berlin,' vol. viii, 1893, p. 81) says that he is doubtful whether it attacks living Oysters. E. J. Allen ("On the Fauna and Bottom Deposits, etc.,' 'Jour. Mar. Biol. Assoc.,' vol. v, (N. S.), 1897–9, p. 474) says that it does great damage on oyster-banks.

It has been said that the Sun-Star (*Solaster papposus*) is poisonous to some animals,* but the following observation suggests that the rays at least do not injure a Purple-tipped Sea-Urchin which eats them. A portion (8 mm. in length) of a ray was removed from a Sun-Star on August 6th, 1915, in the course of certain experiments upon the capacity for ray-regeneration in that asteroid, and the amputated ray was then (10.30 a.m.) immediately given to a little Sea-Urchin of 10 mm. in diameter. The Sea-Urchin began at once to eat the ray, and it was engaged in its meal, at the place where it began it, until 11 a.m. on the 8th, by which time no fragment of the ray could be discovered. The Sea-Urchin appeared to suffer no ill-effects, and is still (February 26th) alive and well.

The Sea-Urchins will devour relatively large quantities of skeletons of echinoderms, just as they will devour shells and exoskeletons of crustaceans. On July 29th the end portions (each about 33 mm. in length) of two rays of a Common Starfish, which had previously been completely skeletonised in potash, were placed on a horizontal rock close to two Sea-Urchins. The latter began to eat the skeletons, and when two other Sea-Urchins were placed close to them they also joined in the meal. Next morning (30th) only a few tiny fragments of the white skeletons were to be seen. On the same day (30th) about one-third of the test of an average-sized Edible Sea-Urchin (*Echinus esculentus*) was broken up and thrown into the aquarium. On August 2nd there were added broken skeletons of an average-sized Sun-Star and of a large Purple-tipped Sea-Urchin, together with the broken whelk shell already mentioned (p. 88). By August 9th none of this material was to be seen, excepting several of the larger pieces of the test of the Edible Sea-Urchin and the harder parts of the whelk shell, which still remain uneaten. It seems probable that the spines which fall from living Sea-Urchins are eaten by other Sea-Urchins—they certainly soon disappear from the aquarium—but a Sea-Urchin has not yet been detected in the act of eating a spine. Eichelbaum, it is interesting to note, found spines of echinoids (species not mentioned) in three of his eleve examples.

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* C. A. Parker (in a Note in the 'Zoologist' of 1881, vol. xxxix, pp. 214–5) records the death of two cats, one within a quarter of an hour, and the other in about two hours, after eating a Sun-Star.

Polyzoa.—The remains of polyzoans, all of which were *Membranipora*, were found by Eichelbaum in six cases. Living colonies of *Membranipora pilosa* have been largely eaten by the Sea-Urchins studied by me. The *Membranipora* may simply be eaten along with seaweed which it encrusts, or it may be scraped away from a hard substance. Several Mussels, whose shells were nearly covered with *Membranipora pilosa*, have been persistently scraped by the Sea-Urchins, and the polyzoans eaten. Fronds of the Sea-Mat (*Flustra foliacea*) also have been devoured.

"*Worms.*"—Worms, including the bodies and tubes of polychætes, tubes of *Pectinaria*, and Spirorbs and Serpulids, were found by Eichelbaum in eight cases. A Sea-Urchin has been seen by me to perch itself on the top of a living Sting-Winkle, and then to eat the empty tubes of *Serpula* which were attached to the shell of the mollusc. Masses of *Sabella penicillus* have been attacked, and portions of the tubes, and sometimes the worms, eaten. *Spirorbis* is eaten in considerable quantity along with the seaweeds to which it is attached.

Cœlenterata, Porifera, and Protozoa.—Eeichelbaum found remains of hydropolyps in eleven cases; these were mainly of *Obelia*, but also of *Campanularia*. Traces of sponges and sponge-spicules he found in five Sea-Urchins, in two instances these being the remains of *Esperia*. Protozoans, mostly rotalids, occurred in eleven cases. The Sea-Urchins observed by me have eaten living and dead masses of *Obelia* and *Hydrallmannia falcata*, and small sponges attached to seaweeds.

2. Vegetable Matter as Food.

The remains of plants, which included diatoms and fragments of algæ, were found by Eichelbaum in each of his eleven Sea-Urchins. Allen mentions a small Sea-Urchin, living in a shallow dish of sea-water for several months, which devoured large quantities of red seaweed.* Petersen, according to Eichelbaum,† mentions remains of plants and diatoms found in the Sea-Urchins.

When the contents of the intestines of Sea-Urchins are examined, the recognisable fragments may consist mainly of those of animals, but observation of the habits of captive specimens suggests that by far the greater portion of their food in the sea consists of plants. The quantity of seaweed devoured in the aquarium by Sea-Urchins is very large. The echinoids will remain in the midst of a mass of seaweed for weeks at a time, constantly devouring it, until the seaweed has become reduced to heaps of fæcal pellets. Any kind of seaweed seems to be acceptable to the Purple-tipped Sea-Urchin. Dead or living *Corallina*, and *Zostera marina*, are readily eaten.

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* E. J. Allen, *loc. cit.*, p. 474.

† *Loc. cit.*, p. 225.

3. INORGANIC MATTER AS FOOD.

The Purple-tipped Sea-Urchin will swallow sand and shell-gravel in the absence of other food. Eichelbaum mentions that he found materials of the sea-bottom (*Bodenmaterial*) in eleven of his Sea-Urchins, and he quotes Petersen has having found fragments of calcareous matter and sand.

It has already been mentioned that such substances as the skeletons of echinoderms (p. 89), shells of molluscs (p. 86), and exoskeletons of crustaceans (p. 84), consisting wholly or largely of inorganic matter, are eaten by the Sea-Urchins. These materials, it should again be observed, are not necessarily taken only by hungry individuals, nor only by certain individuals. This curious habit is being made the subject of further observations, but it may here be added that the Sea-Urchins will devour the ordinary chalk prepared for use with the blackboard. For example, on the afternoon of September 7th, a Sea-Urchin of 19 mm. was given a piece of chalk, measuring 39 mm. in length, and 12 mm. in diameter at its thicker end. The Sea-Urchin raised itself so that its teeth could be brought to bear on the rim of the narrower end of the piece of chalk, and it could clearly be seen to drive the points of its teeth into the chalk and then take the fragments into its mouth. The animal was still upon the chalk at 10 a.m. next day. The chalk was now removed for examination, and it was found that it had been bitten so that the portions shown in fig. 1, D had been removed. The peculiar impressions made by the teeth of the Sea-Urchin are also shown in the fig. (*d*, *d*). Small pieces of chalk are now given to the Sea-Urchins from time to time.

On seven occasions Sea-Urchins have been directly observed to bite repeatedly small pebbles, but without any effect so far as could be seen. The floor of that aquarium in which the twelve Sea-Urchins are contained is covered to a depth of about two inches with small pebbles; and it may often be that when the animals are stationary on the bottom, they are at that time engaged in biting the stones; but it is, of course, only possible to make sure of what they are doing when they are in favourable positions close to the glass.*

On reviewing the foregoing observations on the food and feeding habits of the Purple-tipped Sea-Urchin, one is struck by the very great variety of its foods, which range from fish to seaweeds, and excrement to shells.

4. The Search for Food.

Casual observation of well-fed captive Sea-Urchins, or of individuals in rock-pools, might perhaps give one the impression that it is the habit of a Purple-tipped Sea-Urchin to meander over the bottom of the sea and simply take the food with which it meets. If, however, a number of healthy and hitherto well-fed Sea-Urchins are starved for four or five days, their actions, when food is placed in the aquarium, show that the animals have quickly become aware of its presence and that they are searching for it. The first sign given by a Sea-Urchin that it has detected food is the extension and eager waving in the water of those tube-feet which are on the area of the animal nearest to the food. Indeed, a Sea-Urchin may sometimes be seen with those tube-feet which are nearest to the food extended and in motion, while those which are further away are contracted and quiescent. The next sign is movement, at first slow, but gradually quickening, in the direction of the food. This is usually accompanied or followed by protrusion of the extensile mouth-membrane towards the food, and alternate opening and closing of the teeth. In a journey towards distant food, a Sea-Urchin will laboriously surmount numerous obstacles, such as piles of rocks, which may lie in its path. Descriptions of two experiments upon the ability of captive Sea-Urchins to detect and eventually to reach distant food will here be presented.

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* It has long been known that *Echinus miliaris* can bore into certain rocks (see F. Cailliaud, "Observations sur les Oursins perforants de Bretagne," 'Rev. et Mag. de Zool.,' Ser. 2, T. 8, 1856, pp. 158–79); and there is a considerable literature relating to the boring of other species, such as *Echinus lividus*. The teeth are apparently the chief agents in boring.

First experiment.—A plan of the glass front of the aquarium is given in fig. 2. The tank contained about 26 gallons of thoroughly aerated sea-water, and the water was kept in constant movement by means of an air-pump. Of the twelve Sea-Urchins (which had been in captivity for twenty-nine weeks, and were perfectly healthy), four were visible, and the other eight were hidden behind the piled rocks at the back of the aquarium. Two of the visible Sea-Urchins, each of 23 mm. in diameter, were on the glass at the places indicated by letters A and B ; a Sea-Urchin of 16 mm. was partly imbedded in the pebbles of the bottom at C, immediately behind the glass; and one of 19 mm. upon the pebbles, also just behind the glass, at D. The time selected for the beginning of the experiment was when the Sea-Urchins were found in a quiescent state, in order that the first signs that the animals had discovered the presence of the food might be observed. Three large fronds of *Laminaria* were placed at 9.30 a.m. on the floor of the tank immediately behind the glass at the place numbered 1. The routes followed by the Sea-Urchins in travelling to the food are indicated by dotted lines.

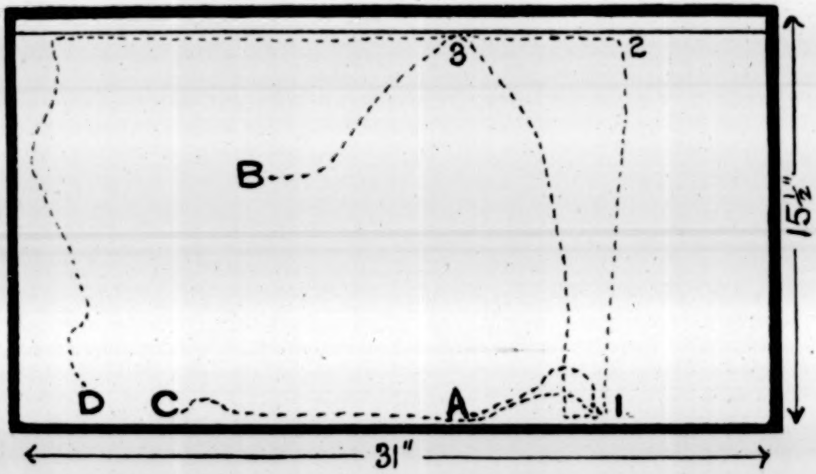

Fig. 2.—Plan of glass front of aquarium to show the routes taken by four Sea-Urchins when seeking *Laminaria*. Thick black line, frame of aquarium ; thin line, surface of water ; dotted lines, routes of Sea-Urchins ; A, B, C, D, starting points of Sea-Urchins ; 1, position of *Laminaria*.

Sea-Urchin A, which was 6 in. distant from the seaweed, showed the customary signs of excitement almost immediately after introduction of the food, and within about twenty seconds had begun to move towards it. It moved a little out of the direct path, as shown in the plan. It reached and began to eat the seaweed in the tenth minute after starting on its journey. Sea-Urchin B, which was 19 in. away from the seaweed, detected the presence of the *Laminaria* almost immediately after A. It at first went astray towards the surface of the water. At point 3 it turned quickly downwards again, and reached the food in twenty-nine minutes after starting. C and D, which were respectively 19 and 21 in. away from the seaweed, showed no signs of excitement until the twelfth minute. C then lifted itself from the pebbles and moved towards the food, at first quickly and then more slowly, reaching the seaweed in 160 minutes. D moved excitedly, but from the first wholly in the wrong direction. When it reached point 2, however, it turned downwards and travelled directly towards the food, but at what time it reached the latter was not observed, the only remark preserved in my notes being that it passed point 2 at 110 minutes after starting. The constant circulation of the water is perhaps the cause of the inability of the Sea-Urchins to go directly towards distant food. A Sea-Urchin of 10 mm., which hitherto had been completely hidden amongst the rocks, unexpectedly made its appearance after thirty minutes. This animal must have been fully 24 in. distant (in a straight line) from the food, to reach which it had to traverse probably not less than 4 ft. of rock surface. The exact time at which it reached the seaweed is not known. On the following morning two other Sea-Urchins, in addition to the five mentioned above, were found on the seaweed.

Second experiment.—The second experiment was made two weeks later, the Sea-Urchins again being starved for a few days; but in this instance the seaweed was suspended from the surface, and this had unexpected results. A view of the left portion of the contents, consisting mainly of piles of loose rocks, of the same aquarium is given in fig. 3. The reader is supposed to be looking through the glass front, and also somewhat downwards upon the bottom, of the aquarium, the bases of the piled rocks being about 2 in. from the glass. At the moment when the

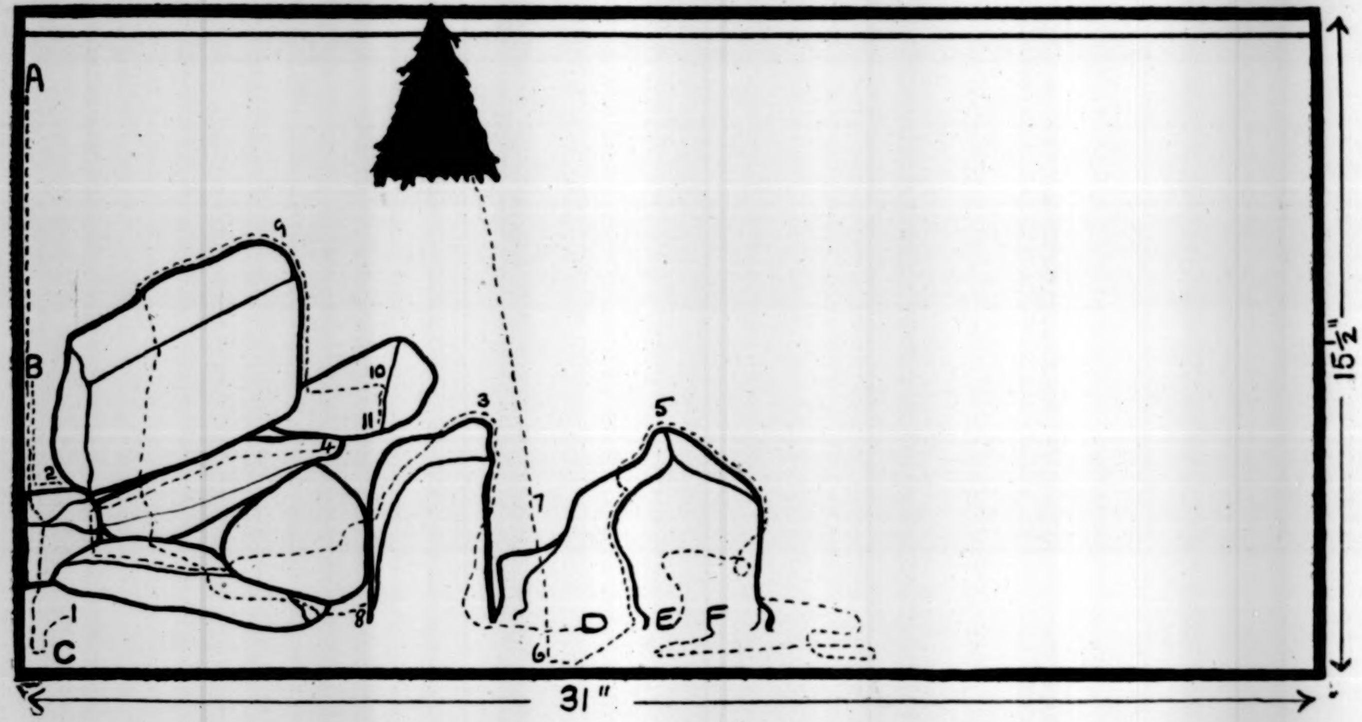

FIG. 3.—View of aquarium containing piled rocks, to show the routes taken by five Sea-Urchins when seeking *Fucus*. The bunch of *Fucus* is represented in black.

experiment began six Sea-Urchins—lettered respectively A, B, C, D, E, and F—were visible, A and B being attached to the left side of the tank, about 2 in. from the glass, and D, E, and F on the bottom between the base of the rockwork and the glass. At 10.30 a.m. a large, closely-tied bunch of fresh *Fucus vesiculosus* (represented in black in the fig.) was suspended from the upper margin of the tank in such a way that the widely-spreading ends of the fronds almost touched the glass. Sea-Urchin C was wholly occupied in biting an inverted Periwinkle, and it took no part in the proceedings described below.

Sea-Urchin A, 23 mm. in diameter, which was about 7 in. distant from the seaweed, showed signs of excitement in the course of the eighth and ninth minutes. It raised the lowermost part of its body towards the food, holding fast to the side of the tank by the tube-feet of its uppermost part; but as it found it impossible to leave the side of the tank, it naturally moved very slowly further and further towards the bottom. It reached the point numbered 1 on the bottom, after several stoppages in its course to attempt to find a direct path towards the seaweed, in 240 minutes after starting on its journey. Here it remained. Sea-Urchin B, of 27 mm., also moved very slowly down the side, reaching point 2 in 250 minutes. Here it too seemed confused, and gave up the search. D (27 mm.), E (23 mm.), and F (21 mm.) seemed to become aware of the food at nearly the same time as A, that is, about the ninth minute after introduction of the *Fucus;* but E from the first displayed the most eagerness of all the echinoids to reach the food. The persistence of these three animals in mounting rocks and lifting up a part of their bodies towards the inaccessible seaweed was very striking, and it must here be emphasised that whenever one of them reached the uppermost part of a rock it would remain there for a short time, as though vainly endeavouring to find a solid foothold which would enable it to reach the seaweed. D moved slowly and irresolutely along the base of the rocks, and then moved quickly to point 3, which it reached after 95 minutes. It searched the water with its tube-feet in the way just described for about one minute, and then moved slowly to 4, which it reached in 360 minutes. E travelled to 5 in 9 minutes, remained there for about 30 seconds, and then moved to the floor again.

It crossed the floor, and when it touched the glass at point 6 it climbed quickly up, stopping for 30 minutes at point 7 to eat part of a *Rissoa* which lay in its path. It then dropped the remains of the mollusc, and mounted quickly and directly to the seaweed, which it reached in 6 minutes after leaving point 7 and 142 minutes after starting. Sea-Urchin F first crept away behind the rocks, and, as it was believed that it had gone astray, its course was not for the time being observed. At 242 minutes after starting, however, it reappeared from behind the rocks at point 8. It traversed the rocks to 9, stayed there for 90 seconds with body raised and tube-feet waving; then it moved down to 10, where it stopped for a few seconds; it finally reached point 11 in 360 minutes. As it was now impossible to continue to make detailed notes of the behaviour of the animals, the seaweed was thrown amongst the rocks between points 3, 4, and 11. All the Sea-Urchins were upon the seaweed at 9.15 the following morning, with the exception of C, which was still upon the Periwinkle.

5. The Positions and Postures Adopted in Feeding.

The favourite method of feeding, if one may safely generalise from observation of sixty captive examples, is to enter into the heart of a bunch of seaweed, and particularly into the firm "roots" of such forms as have these in thick masses, and to remain ensconced there. Indeed, it is frequently to be observed that a Sea-Urchin, or several clustered Sea-Urchins, will remain in such a situation until the seaweed has become reduced to fragments and the animals surrounded by loose heaps of fæcal pellets. The Sea-Urchin will bite a hole in a frond of seaweed, but it usually begins at the edge or at a place where there is already a break or perforation.

A Sea-Urchin readily adapts its posture to the needs of biting food which is difficult to reach. One end of a long and narrow frond will often be held with spines and tube-feet against the teeth, in a way which absurdly suggests the smoking of a cigar, and then be gradually eaten away. In the case of a firm frond projecting from an otherwise inaccessible bunch, the animal will raise itself on its rim, so that its teeth are at right angles to the floor, and then eat along the seaweed. A Sea-Urchin will often lie on its aboral surface whilst eating inconveniently placed material; and in order to hold and eat a bulky piece of food will sometimes climb a vertical rock with its mouth directed outwards. A living *Ascidia* of 30 mm. in length was placed upon the uppermost part of a Sea-Urchin of 23 mm., which was climbing up a vertical rock, and the Sea-Urchin, which seemed quite able with its spines to hold the smooth Ascidian, at first endeavoured to place its prey beneath the mouth, but the Ascidian was too bulky to lie between the Sea-Urchin and the rock. The Sea-Urchin then slowly turned completely over, holding firmly to the rock and the prey, and the echinoid began to eat the Ascidian as soon as the former lay with its mouth outwards. The whole process, from the time of placing the Ascidian to that at which the Sea-Urchin began to eat, occupied between nine and ten minutes.

If the food can be moved the Sea-Urchin will often arrange it conveniently under its teeth. A *Rissoa*, for example, is often, but not always, turned in such a way that the pointed end of the shell is directed towards the mouth, and the first (or first and second) whorl of the shell then bitten off. A few *Rissoæ* which had escaped after being so treated have been seen in the aquarium. As was pointed out on p. 88, the hinder parts of the shells of Mussels have been bitten by the Sea-Urchins, and it is probable that this part of the shell was selected because the echinoids were better able to seize with their teeth the narrow edges of the shells than they would be to seize a thicker part. The inverted gastropods on which the Sea-Urchins so often "sit" are probably turned over by the echinoids, though the latter have not actually been seen to do this. A straggling exoskeleton of a shrimp will be gathered into a compact mass beneath the mouth. A Sea-Urchin which found the tube of a *Sabella penicillus* (whose length was four times the diameter of the echinoid) inconveniently long, twisted the tube around its body. A Sea-Urchin of 10 mm. (carrying eleven pebbles of nearly one and a half times its own weight) remained for several hours balanced on a large horizontally projecting *Sabella*, in whose tube a hole was bitten.

6. The Time Spent in Feeding.

The length of time a Sea-Urchin will remain in one place to consume food has several times been incidentally mentioned. Four large individuals remained in a bunch of seaweed for two weeks, at the end of which time it was reduced to a loose heap of fæcal pellets; and five Sea-Urchins remained in another bunch for over three weeks. Three Sea-Urchins "sat" on a large dead Common Hermit-Crab from 10 a.m. on August 16th until 10 a.m. on the 19th, when, owing to its decayed state, the crustacean had to be removed from the water. A Sea-Urchin of 10 mm. remained in one place to eat the ray of a Sun-Star for two whole days, and another one sat on a living inverted Periwinkle for thirty hours. The Sea-Urchin of 19 mm., which ate part of the chalk, mentioned on p. 91, remained on the chalk for nineteen hours.

NOTES ON THE BIRDS OF LINLITHGOW LOCH.

By the Rev. J. M. McWilliam.

Linlithgow Loch lies about three miles south of the Forth, and about sixteen miles from Loch Leven, the breeding haunt of so many species of ducks. Being Crown property, it has the rare advantage of being a bird "sanctuary."

During nearly three years, from June, 1911, till December, 1913, I had constant opportunities of watching the birds that take advantage of its protection. I had previously been able to form some acquaintance, during the nesting season, with the birds of Loch Leven, where the Pintail and Wigeon, and, it is reported, the Gadwall breed ; and as Linlithgow Loch is not very far from Loch Leven, I had hoped that I should find there some of the rarer ducks that nest regularly on the latter lake. I may say at once that the two lakes are more remarkable for the contrast than for the resemblance of their bird-population, though they are perhaps equally interesting; but I shall refer to this contrast later.

Linlithgow Loch is almost a perfect example of what complete protection can do for birds, under conditions in some respects disadvantageous. The lake is only about a mile in length, and a very few hundred yards in breadth. For almost its whole length it lies within a hundred yards or so of a town with a population of four thousand. There is a public park stretching to the edge of the water, and boats constantly out on the lake. And yet, in spite of these disadvantages, ducks of at least eight species can be seen there throughout a great part of the year. Unfortunately, too, there are only a couple of very small islands, and practically no available breeding ground of any kind. If it had been more fortunate in this respect it could hardly have escaped being a second Loch Leven as regards its breeding ducks; but, as it is, hardly any ducks nest here. It is only after the nesting season that the lake is of interest. During part of the three years in which I worked this lake for birds I used a × 12 prism glass, but I soon found that something much more powerful was required; so for the remainder of the time I used a × 26–40 telescope. I was principally concerned with the ducks, but I took records of all of the more interesting birds that I saw. I have no doubt that my list of birds could be added to by any naturalist who gave more prolonged study to the lake. Indeed, I heard casual reports of others having been seen; but I found it difficult to get much accurate information, and so I merely give the results of my own work.

As I said before, it is only in the autumn and winter that many ducks come to the lake. I tried in each case to get the dates of arrival and to form as close an estimate as possible of the numbers of each species.

For the sake of accuracy these notes take the form of extracts from my note-book, written at the time of observation.

Pochard.—This is much the commonest species, about three hundred spending the whole winter on the lake, though none remain to breed. The earliest record that I have is for August 28th.

"August 28th, 1913. A small party of Pochards on the lake to-day."

"September 8th. About a dozen Pochards on the lake."

"September 14th. At least thirty Pochards on the lake."

"September 22nd. I counted seventy-six Pochards."

"October 13th. More than one hundred Pochards on the lake."

The majority of the Pochards, like the other diving-ducks, stay constantly at the deep west end of the lake, but some are always to be found at the other end with the surface-feeding ducks.

I watched a large flock through the telescope one morning in order to settle a point which seems to require to be cleared up. One sees it stated, from time to time, that ducks, while resting on open water during a breeze, keep their position by paddling in a circle with one foot.* I cannot see how anything could be gained by such action, as it is not possible to keep a boat from drifting by rowing with one oar from the side. However, I give some notes which I took, with this theory in view, while the birds were actually under observation through a telescope.

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* See for instance Headley, 'Structure and Life of Birds,' p. 171, where this idea is fully elaborated.

"One hundred and thirty-five Pochards sleeping on the water in a moderate breeze. About half of the number were resting, probably deliberately, in a patch of pond-weed where they would not easily drift, and did not seem to require to correct their position in any way. The remainder were resting further out, and they kept continually crossing and re-crossing the field of view of the telescope, first drifting a few yards, and then moving up-wind again. While doing so they always swam in a straight line, and kept their heads lowered as if asleep, *with their eyes closed.* I noticed one or two that seemed to be turning in the water, but this appeared only due to a chance breeze, and the birds seemed to gain nothing by the movement. Certainly there was no general turning movement to suggest that the birds kept paddling with one foot while sleeping. In fact, the Pochards did not seem to sleep very continuously. I constantly saw them raise their heads for a moment."

The Pochards are amongst the tamest ducks on the lake. They will swim quite boldly within twenty yards or so of people on the shore.

I regret that I did not take the relative numbers of males and females. My recollection is that the males were greatly in the majority, but little weight can be put on this after an interval of a couple of years. It is a point that could be settled in half an hour by any person who went to the lake.

Tufted Duck.—A very few, perhaps six or eight, spend the winter on the lake. The earliest record that I have is for August 24th. None breed on the lake.

Golden-eye.—These ducks are always to be seen during the winter. About twelve is the usual number, perhaps three to five of which are adult drakes, which seems to be an unusually large proportion. I cannot say that I have seen more than four drakes at one time. It is not uncommon to see a female feeding at the very edge of the lake, even at the Palace grounds, where people are continually walking about. Of course, nearly all of the ducks are very tame here, except the Wigeon, and in a lesser degree the Teal. The Shoveller, too, is hardly as tame as the Pochard or Golden-eye. I took the following notes about one

Golden-eye that seemed to be assuming full male plumage, though unfortunately I could never get very close to it:

"October 29th, 1913. I saw at least four Golden-eyes in female plumage, and one that appeared to be a male developing its full plumage. It showed a lot of white on the sides and back, and I thought, though I could not be certain, that I saw traces of the eye-spot.

"November 11th. I had a couple of Golden-eyes in view with the glass for some time at a considerable distance. They were both certainly drakes, but the eye-spot in one did not show as distinctly as in the other. Could this former be the bird that I saw on October 29th?"

October 27th is the earliest date that I have for this species. They always seem to arrive at the very end of that month. Curiously enough, I cannot remember having seen a drake at nearly so close a range as I constantly saw the females. They kept more to the middle of the lake. I am certain that I never saw one within gunshot.

MALLARD.—Some scores of these ducks are to be seen in winter, and a very few breed on the lake. This is the only duck that I have seen here with young. I have seen two or three with a certain amount of white on their plumage. Doubtless these birds occasionally interbreed with tame ducks.

WIGEON.—A very few come, probably every winter. For a few weeks from October 22nd, 1913, I had a male and four or five females under regular observation. It is strange that so few of these birds, and so few Tufted Ducks, come to the lake. The latter is the commonest duck on Loch Leven, and the Wigeon breeds there in some numbers.

TEAL.—About twenty Teal stay during the winter. They seem to assume full winter plumage earlier than most species.

"October 22nd, 1913. I saw several Teal, including half a dozen males in quite good plumage. The head had the chestnut and green markings, and the cream-coloured streak between. I saw about forty Shovellers, one or two of the males showing some signs of getting their winter plumage." The Teal were certainly very much in advance of the Shovellers in this respect. I should not have been surprised if Teal had not been found at

Linlithgow, as they do not breed on Loch Leven in any numbers, so far as I am aware, if they breed there at all. Doubtless they are to be found at Loch Leven in the winter, though this I do not know.

SHOVELLER.—This is one of the most interesting ducks on the lake. I fancy that the usual number is about forty. My earliest record is for August 22nd. I give a few notes as to the dates of their changing plumage:

"August 22nd, 1913. I identified a small party of Shovellers through the telescope. They were perhaps four hundred yards away, and I could see no difference in their plumage from that of Mallard ducks, but the size of the bill was quite obvious."

"October 22nd. About forty Shovellers, one or two of the males showing some signs of getting their winter plumage."

"October 23rd. Some of the Shovellers show distinct signs of getting their winter plumage."

"October 27th. The Shoveller drakes are fast getting their full plumage. Several of them have a considerable amount of white on the breast and chestnut on the sides."

"November 4th. Some of the drake Shovellers have practically full plumage."

"November 18th. It is certain that all of the members of a species do not change their plumage at exactly the same time. There are Shovellers on the lake in several stages at present. Perhaps the young of the year are the latest to change, and one would fancy that with the adults the time bears some relation to the date of their nesting. Birds which nest early would probably change their plumage proportionately early."

"November 22nd. I saw perhaps a dozen Shovellers, but none of them in nearly full plumage. Possibly they may only stay here during the transition, but they may quite possibly only have been away from the lake for the morning."

I have a strong suspicion, which unfortunately I had not the time to verify, that all of the Shovellers leave the lake as they complete the change. They became gradually less numerous through November, and I do not think that I ever saw one in absolutely full plumage. Possibly someone might settle this point. If it is as I suggest, it is a fact worthy of note, and there seems considerable reason to believe that it is so.

Goosander.—Several of these were to be seen on the lake during the winters of 1911–12 and 1912–13.

"November 6th, 1911. A flock of six Goosanders on the lake, one of them an adult male."

"November 18th, 1912. I saw to-day a flock of at least a dozen Goosanders on the lake, about half of them being males in good plumage."

In 1913, till I left in December, no Goosanders had appeared. The first that I saw in 1911 were on the lake the morning after a very heavy storm. They were magnificent birds, the whole flock keeping together, the birds diving and plunging through the water at a great pace.

Great Crested Grebe.—I have seen one or two on the lake from time to time, but they are only stray visitors and never nest, though there is some suitable cover for them if they wished to do so. I saw this species on November 18th, 1912, and on September 16th, 1913.

Little Grebe.—There are one or two pairs of these. I believe that I have seen the young.

Coot.—Common and resident.

Waterhen.—Common and resident.

Cormorant.—These are constant visitors to the lake. I have seen three or four at a time sitting on the trees on the little islands. They constantly fly to the lake from the Forth, and fish for an hour or two before leaving.

Heron.—These are constantly to be seen at every season of the year, but they do not nest.

Snipe.—I have seen three or four of these at different times.

Sandpiper.—I have seen these on several occasions.

Redshank.—I have seen very few. On October 29th, 1913, I saw a flock of three or four.

Gulls.—The Herring-Gull, Common Gull, and Blackheaded Gull are to be seen constantly, the Herring-Gull being in flocks of hundreds at times. The Lesser Black-backed Gull is numerous in spring, but I cannot say that I have seen it in winter. The Great Black-backed Gull comes in small numbers, usually, I believe, in winter. Sometimes I could not decide which of these two latter species I was watching through the glass, but I could generally identify them by comparing their size with that of Herring-Gulls swimming beside them.

I have seen a very few Terns from time to time, but never sufficiently close to decide whether they were Common or Arctic.

This forms the complete list that I was able to compile of what might reasonably be described as lake birds.

The contrast in many respects between the Ducks frequenting this lake and those of Loch Leven struck me. I never saw or heard of either Pintail or Gadwall on Linlithgow Loch, though they breed on Loch Leven. The Tufted Duck is the commonest breeding bird on Loch Leven, and half-a-dozen only were to be seen at Linlithgow. Wigeon breed regularly at Loch Leven; they were very rare at Linlithgow. Teal were common on Linlithgow Loch, and they certainly do not breed commonly on Loch Leven. The Shoveller and the Mallard were the only two whose status on the two lakes seemed to be about the same. They were both reasonably common on each. The Pochard was the commonest Duck at Linlithgow Loch. I believe that it breeds on Loch Leven, but probably not commonly. Of course, I am writing only from experience of Loch Leven during the summer; but still it is surprising that so many Ducks that nest regularly there seldom or never come to a lake only sixteen miles distant that is so much frequented by other species as Linlithgow is. On a few occasions I was puzzled in identifying certain birds at Linlithgow, but I certainly never had a clear view of Ducks other than those that I mention.

I do not know if I have made it quite clear just how interesting the birds of Linlithgow are. It is the commonest thing to have Ducks of five or six species in view at the same time. For months during the winter there is hardly a day when there are not some hundreds of Ducks to be seen at a reasonable range. One can examine by the hour birds that in most other places are almost unapproachable. The only regret of the naturalist is that there is no suitable breeding-ground. If the lake were even in the hands of a private owner who was interested in birds this could easily be remedied to some extent. But, as things are, there must be few places in Britain that give opportunities for bird-study of the same kind. I have no doubt that the list of birds that I have given is imperfect. In working out even the easier problems in natural history it is seldom that one has not to leave much unfinished. Perhaps someone may complete these records in the future. In fact, there are few things more interesting to an ornithologist than the changes that have taken place of recent years in the status of many of the British Ducks. Several species that were quite rare a generation ago are now amongst the commonest; and I suspect that some species, such as Mallard and Teal, are in many places rarer than they used to be. It would be of substantial interest if a more or less continuous record could be kept of the Ducks in some particular place, such as Linlithgow Loch, which is not much affected by changing local conditions. The numbers of the different Ducks that I have given were ascertained as carefully as was reasonably possible. What will be the relative numbers of the different species in, say, ten or twenty years? Perhaps some person who is permanently resident in the district might continue these records. From the peculiar situation of the lake it could be done without much difficulty.

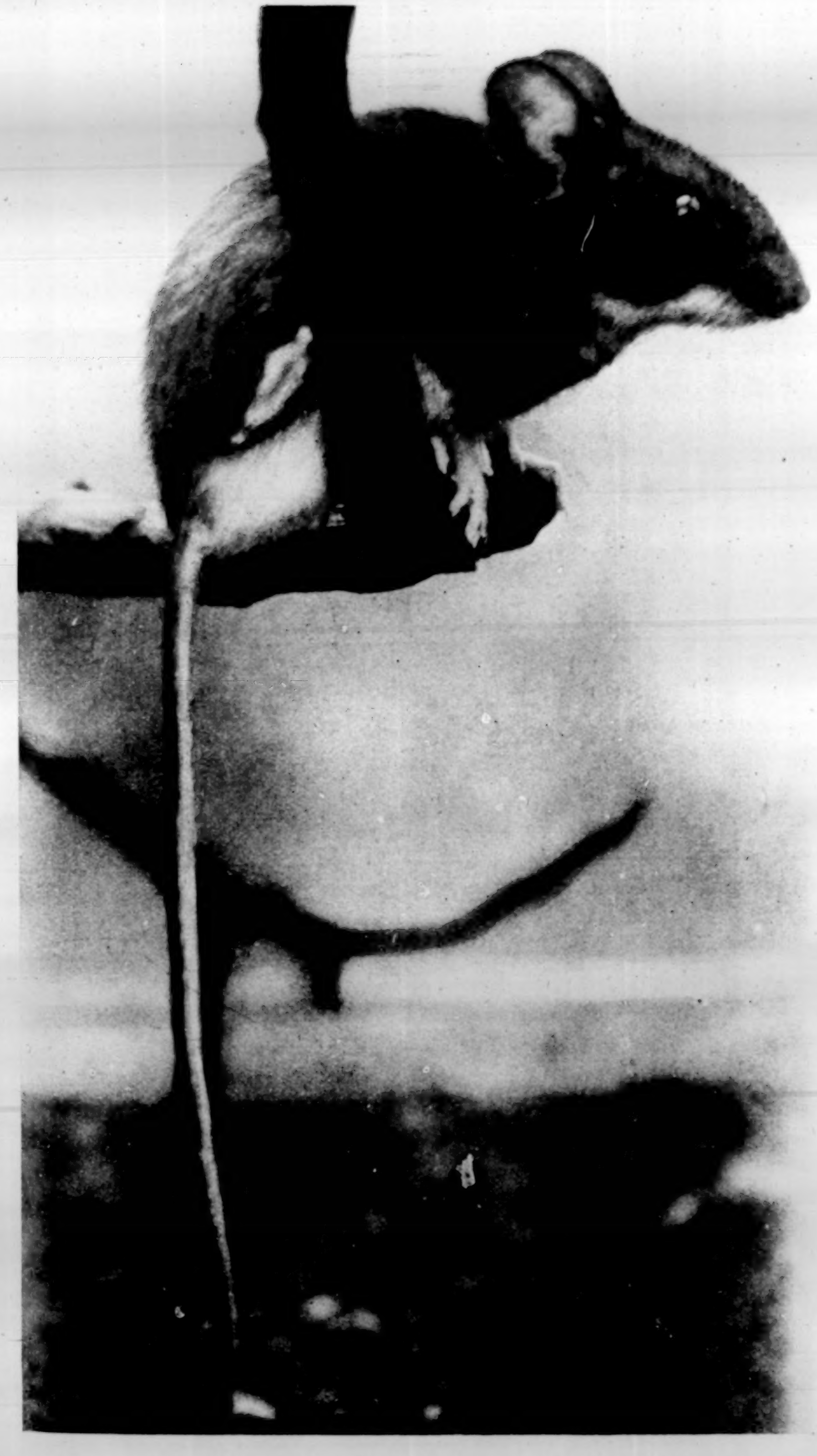
THE YELLOW-NECKED MOUSE IN SHROPSHIRE.

By Frances Pitt.

This handsome variety or sub-species of the Long-tailed Mouse (*Apodemus sylvaticus*) was formerly considered rare in Shropshire, only two or three isolated examples having been taken; but in the summer of 1913 I found that *A. flavicollis wintoni* (Barrett-Hamilton) was very common in this neighbourhood, *i. e.* the district around Bridgnorth.

I have taken many specimens alive and kept them in captivity, and have had the pleasure of noting several interesting facts concerning them. In life the difference between the two races is far more marked than an examination of a series of skins would lead one to suppose, and its superior size, brighter colouring, longer tail, its heavier build, and the fawn collar, from which it takes its name, make the Yellow-neck by far the handsomer Mouse of the two. There is no difficulty in distinguishing it, even when running about, and the typical *sylvaticus* appears dull and dark beside its larger relative. It is *flavicollis* which is the "Greyhound Mouse" of the country-people, and they have good cause to know it, as it is a most determined thief of such things as peas, potatoes, etc.

Nearly all the Yellow-necks that I have caught have been taken in the house, usually in the larder and cellar, where it has been quite the exception to catch a Long-tailed Mouse, though a trap set out of doors has been just as certain to capture a Long-tail. I have many times placed a trap beneath a bush in which some old bird's-nest bears witness, by the remains of the berries it contains, that there is a Mouse about, but the result has invariably been the capture of a *sylvaticus*. But it is different when you get to the neighbourhood of buildings, where the chances seem to be equal, and inside (failing the Common House Mouse!) it is just as certain to be a Yellow-neck.



YELLOW-NECKED MOUSE, MALE (LIFE-SIZE).

Apodemus flavicollis wintoni (BARRETT-HAMILTON).

Photo. by F. Pitt.

The proportion of the sexes in this neighbourhood seems to be about equal (I understand that observers in other parts of the country have found a preponderance of females), and the evidence points to the adults going about in pairs, for whenever I have trapped a Mouse of one sex I have invariably taken another of the opposite sex on the same spot shortly after. Once I caught them together! Something had been eating holly-berries on a bedroom window-sill, and suspecting a Yellow-neck I put, not having a proper trap handy, an ordinary box-trap baited with a piece of cheese—by the way, though Long-tailed Mice of both races refuse cheese when offered them as food, yet it is the best of all baits; the reason, I suppose, being that they can smell it so far away, and enter the trap to see what it is. On this occasion it was most effective, for in the morning there were two of the finest Yellow-necked Mice that I have seen, tightly wedged in the little trap. They were quite unhurt; even their long tails were not damaged, but how they had both got in I do not know. I put them in a cage and kept them for some time, until they escaped, through an accident. They were beautiful creatures to watch, being wonderfully graceful in their movements and most particular over their toilet; they would sit up and clean themselves in the daintiest manner. It was astonishing what high jumps they took when endeavouring to reach the roof of their cage. I provided them with small sticks and twigs, among which they performed all sorts of acrobatic feats, and there can be no doubt that the Yellow-necked Mouse and the Long-tailed are both quite as much at home up aloft as the more obviously arboreal Dormouse. I have frequently found Long-tails in nests that had been made by the latter species, and as I have seen a Long-tailed Mouse come out of a nest which only the day before had held a Dormouse, I think the presumption is that they often turn out the rightful owners.

When caged the Long-tailed Mouse is usually a most gentle creature, ready to welcome in a friendly fashion any stranger of its own species that may be introduced, and tolerant of other Mice; but my experience of the larger race is that they are far from being so amiable, and my captives have shown so much animosity towards their smaller relatives that I doubt the two races inter-breeding much under natural conditions. The presence of Mice of an intermediate type (but such are far from common), and the fact that I once found a typical *sylvaticus* and a typical *flavicollis* living in the same nest in a bee-hive—the little wretches had destroyed all the bees!—suggests that such crossings may occasionally take place; but I have also known Yellow-necks kill and eat the smaller Mice. In January, 1914, I put seven Mice in one large cage. There were four Yellow-necks, one Mouse of the intermediate type, and two Common Long-tails. At first, as far as I could see, they agreed quite happily, but on the second day I found the Mouse of intermediate type dead and partly eaten. In two days another one was killed. This was a small male that was really rather of the intermediate type than a true Yellow-neck. Then I investigated the matter. I found a fine old male *flavicollis* with two females in a nice nest in one corner of the cage and the *sylvaticus* pair at the opposite end, where they also had made a nest. One of them had been bitten, and I removed them and put them by themselves. Thinking the matter over, I thought it might only be a case of a big powerful male bullying the smaller ones; so I decided to see what would happen to a Short-tailed Meadow-Vole, for if it were only a case of the males fighting they would surely not interfere with a Mouse of a different species. I put the Vole into the Yellow-neck's cage and awaited events. It ran about and nibbled at the grass which I had provided for it, and soon one of the big Mice peeped out of the domed nest. Its great beady eyes looked this way and that, and its nose worked in a manner that showed it smelt a new-comer. Very cautiously it stepped out, paused and sniffed, then with a bound it attacked the Vole. There was much squeaking and scuffling, and the poor little stranger was chased round the cage, and I have no doubt would have been killed had I not interfered and rescued it; but it had already been bitten in the leg.

It seems that the Yellowed-necked Mice are intolerant of the presence of Mice of other species, and even object to nearly allied forms. Surely this trait in the character of the race will be a powerful factor in bringing about segregation? And that *flavicollis* and *sylvaticus* are an example of how two varieties inhabiting the same locality will split into well-marked and distinct species by reason of the preference like has for consorting and breeding with like?

To go back to the Yellow-neck in Shropshire. I think that this Mouse and the Long-tail have two migrations—namely, from the neighbourhood of the farm-buildings and stacks in the early summer to the woods and open fields, and a return migration in the late autumn when the supply of berries, etc., runs short. Many, of course, do not leave the woods and hedges, but these are chiefly of the *sylvaticus* type. I have never caught a Yellow-neck in the open in the winter, though I have taken many Long-tails. And the same applies to the Mice which are ploughed up in the stubbles during the autumn ploughing, many dozen of which have passed through my hands; but they have all been of the dull, dark *sylvaticus* type.

By the way, though the young *flavicollis* in its first pelage resembles the smaller variety, yet it can easily be distinguished, for the mark across the throat and chest which afterwards becomes the distinctive fawn collar is visible even at this early age as a darkish grey streak.

Apropos of the difference in size between the adult Mice of the two varieties, I may mention that, whereas the Long-tail can get out easily and without much squeezing through the small wire netting which is known as "½ in. meshing," yet the Yellow-neck is safely imprisoned by it, and with his bigger skull cannot pass through. As series of measurements may be found in any text-book, I do not propose to give any here, but will only say that in life the difference in size is as obvious as that between a small pony and a big cob.

The distribution of this handsome Mouse does not seem to be very well worked out. It is known that it is scattered sporadically through the south and west of England, but I am convinced that in many localities it is overlooked, so I should be very glad if anyone who has met with it would communicate with me.

NOTES AND QUERIES.

MAMMALIA.

Dissimilar Eyes in Human Subject.—A short time ago I noticed a girl of about twelve years of age with a striking peculiarity—her eyes were not alike: one being dark blue and the other dark brown. Apart from this she was quite ordinary—black eyebrows and lashes, a bright healthy complexion, and thick brown hair.—(Miss) F. R. Holloway.

AVES.

Missel-Thrush Feeding at London Window.—On the snowy morning of February 24th, I put some crushed biscuit on my window-sill, in hopes of attracting a pair of Starlings which reside in this region of small back-yards (Chalcot Crescent, N.W.), as well as the Sparrows. They did not come, but to my great surprise, a Missel-Thrush did, and after eating some biscuit, came again in about half an hour, accompanied by another; these birds showed even less nervousness than the Sparrows, and after feeding remained a little time on the neighbouring trees, but they did not appear again, though I had the food ready next morning. Probably they left the neighbourhood; I saw three flying south over Euston Road about noon that day. In so shy a species such tameness seems to be strange, though the few Regent's Park Missel-Thrushes are, of course, used to the sight of people; I have, however, never seen any Thrushes at all from this window before, though Blackbirds not infrequently appear, and I have seen one feeding in a yard.—F. Finn.

The Little Owl in Sussex.—The Little Owl (*Athene noctua*) first came under my notice in this district in April, 1913, but I failed to authenticate it at that time, and it was not until last December (1915) that I again met with it, when on the 28th of that month I saw one in Buxted Park. I found it at the same spot on the following day.—Robert Morris (Uckfield, Sussex).

A Sussex Marsh-Harrier.—On October 26th last there came into my possession a fairly well-mounted immature Marsh-Harrier (*Circus æruginosus*), shot some years ago by the late Mr. William

Sturt at Crosbury, Little Horsted, Sussex. It was purchased at a sale of the effects of the late Mrs. Sturt at Jarvis Brook, Crowborough, some few days previously. Mrs. Green, of Hove, very kindly offered to obtain some information as to the year in which it was obtained, and wrote her brother, Mr. Charles Sturt, who, though he well remembered the bird being brought home, could not give the date, further than it was between forty-five and fifty years ago. Judging by the plumage I suppose it to be a male. I thought it as well that this should be recorded.—ROBERT MORRIS (Uckfield, Sussex).

CRUSTACEA.

Ecdysis in a Hairy Hermit-Crab.—The habits and the rate of casting of the exoskeleton of the hairy Hermit-Crab known as *Eupagurus pubescens* seem to have been little observed in captivity. An average-sized individual in an aquarium cast its exoskeleton on July 7th, and again on August 18th, of 1915. The animal was healthy, and fed eagerly on pieces of mussel and beef. It disappeared on October 26th without having cast again, and presumably it had either escaped from the aquarium or been torn to pieces by the larger Common Hermit-Crabs in the same tank. The number of clear days which elapsed between the two castings was therefore forty-one. Sixty-eight clear days elapsed from the date of the second casting to that of the disappearance of the Hermit-Crab.—H. N. MILLIGAN.

Shore-Crabs Attacking Opelet Sea-Anemones.—On September 9th five average-sized individuals of the Shore-Crab (*Carcinus mænas*) were placed in an aquarium. On the 16th about twenty examples of the Opelet Sea-Anemone (*Anthea cereus*), varying in size from half an inch to three inches and a half across their extended tentacles, were placed in the same tank. The Shore-Crabs have never hesitated to attack the Sea-Anemones, and to tear off, and in some cases actually to eat, their tentacles. The Shore-Crabs would also rob the Sea-Anemones of food by thrusting their claws amongst the tentacles, or into the food-cavities, of the Sea-Anemones and dragging out the food recently taken. The Shore-Crabs never seem to sustain any damage in these encounters, or even to be perturbed in any way by the presence of nematocysts when they take the tentacles into their mouths. The Sea-Anemones underwent so much persecution that on November 16th they were removed from the aquarium. The curious mixture of delicacy and hardiness so often displayed by the Opelet Sea-Anemone in captivity is well known, and it is interesting to observe that in spite of persecution these coelenterates are still

(December 23rd) nearly all alive and flourishing, that the wounded stumps of their tentacles have closed up, and that the tentacles are apparently beginning to regenerate.—H. N. Milligan.

INSECTA.

Butterfly Abroad in Dull Weather.—Two or three years ago I noted, on a dull drizzly day, a large white Butterfly flying along the window-boxes in a London street, feeding on the flowers, exactly as if in sunshine.—F. Finn.

ASTEROIDEA.

Starfishes Feeding on Hermit-Crabs.—Dr. Bolau has recorded (Kleinere Mitteilungen, in "Der Zoologische Garten," vol. xlvi, 1905, p. 53) his astonishment on discovering that his Starfishes fed on living Hermit-Crabs in an aquarium. I have fed Common Starfishes with dead Hermit-Crabs, and have found that they are readily taken. One Starfish "sat" from the morning of December 3rd until the morning of the 4th on a *Turritella* shell in which there was a healthy Hermit-Crab of the species known as *Eupagurus pubescens*; but it seems that the Starfish had merely fastened its stomach on the shell, not on the Hermit-Crab itself, and the latter appeared to be none the worse for the encounter when I released it from the grasp of the Starfish on the 4th. Earlier in the year I gave a sluggish Common Hermit-Crab (*Eupagurus bernhardus*) of average size to a Starfish of medium size at 10.15 a.m., and the former was at once attacked by the latter. The Starfish humped over the shell of the crustacean; fixed the shell firmly in the angle between the glass front and the floor of the tank, by fastening two arms to the glass and the other three to the floor; and then it pulled the Hermit-Crab bodily from the shell. The Starfish quitted its prey at about 10.15 a.m. on the following day. It was found on examination that the skin of the crustacean had been punctured at the place where the abdomen joins the thorax, and the greater part of the soft contents of the abdomen and the thorax had been extracted, leaving little but the empty exoskeleton. This is an excellent example of the way in which the Common Starfish will pass its stomach through a small opening in the body of prey and search its interior. The emptied abdomen of the Hermit-Crab collapsed when it was lifted from the water, but the abdomen had not been separated from the thorax.—H. N. Milligan.

NOTICES OF NEW BOOKS, Etc.

A Monograph of the British Marine Annelids. Vol. III. Part I.—Text. Part II.—Plates. By PROFESSOR W. C. McINTOSH, F.R.S., etc. London: Dulau & Co., Ltd. 1915. Price 25*s.* each.

THE present instalment of the Ray Society's well-known monographs deals with the Polychæte marine Worms of eleven families, from the *Opheliidæ* to the *Ammocharidæ*, including over eighty species. Thus, as is said in the Preface, "in this Part economically valuable forms, such as the Arenicolids and Spionids, brightly phosphorescent types like *Chætopterus*, the most cosmopolitan of all the boring groups, viz. the Polydoræ and Dodecaceridæ, the complex and physiologically interesting *Magelona* and the Capitellidæ, and, lastly, the numerous and peculiar family of the Maldanids, fall to be considered." Professor McIntosh, in an admirably concise and lucid style, deals most fully with the structure, colours, habitat and habits—where ascertainable—and anatomy of these interesting organisms, and many facts of interest to the general naturalist, as well as to the student of marine life in general and of annelids in particular, come to light in the course of the work. It is interesting, for instance, to read of the familiar Lob-worm (*Arenicola marina*) of such importance to fishermen for bait, that the process of breaking up and fixing it for this purpose is so trying to the fingers, unless dipped beforehand in a solution of alum, that they soon bleed owing to the friction and the secretion produced by the worms; and that the hæmoglobin in the blood of these differs little from that of such a different creature as the Horse. Of the curious tube-living *Chætopterus variopedatus*, so remarkable for its enormously-developed and greatly-varied appendages, "it is," says Professor McIntosh, "most beautifully phosphorescent, bright flashes being emitted from the posterior feet, but the most vivid light occurs on the dorsum, between the great sickle-shaped lobes which curve forward over the first region of the body. Here the phosphorescence is intense, and the copious mucus exuded by the animal can be drawn out as vivid bluish-purple fire which, besides, now and then gleams along the edges of the wing-like flaps, illuminating the water around." Although commonly found in deep water, this interesting worm occurs, at Herm, under stones in pools between tide-marks. The synonymy of the groups dealt with is most completely and conveniently given, the references being given strictly in chronological order, a plan which, though it uses up a good deal of space owing to the consequent repetition of names, more especially as each reference has a line to itself, is thereby of great assistance to the ready finding of a particular reference. It is worth noting that the common *Arenicola marina* was described as *Lumbricus marinus* by Belon as long ago as 1553; and the references to it between that date and the present day fill up no less than five pages of this publication in quarto—a most unwieldy size, by the way.

Part II. contains the plates illustrating Part I., the only illustrations in which volume are line drawings in the text illustrating anatomical and other details. These plates, numbered lxxxviii to cxi, depict both the whole animals and various details of structure, such as bristles, etc., and are most beautifully executed, reflecting the greatest credit on the artists, Miss A. H. Walker and the late Mrs. Albert Günther. Six of them—lxxxviii. to xciii—should have been in colour, but owing to the war it has proved impossible to get these through, and so all have, very rightly in our opinion, been issued in black and white, to render the text at once available to workers. If ultimately obtainable, the coloured plates are to be sent to subscribers for 1916. We might suggest that these would find it interesting and useful to colour these black and white plates themselves, as opportunities occur of getting living specimens. We have here a small criticism to make—the degree of magnification is generally given in the detail figures, but those of the whole animal are generally spoken of merely as "enlarged"; a more precise indication of the degree of enlargement would, we think, have been of service to collectors unused to this group. We should like especially to draw attention to the figures of the extraordinary pinnate bristles of *Poecilochætus serpens* given on the last plate; these are so extremely like feathers of the simple type consisting only of shaft and barbs, such as some of the Emu's, that no one could, on seeing these drawings alone, think they could have been meant for anything else.

The Invertebrate Fauna of Nottinghamshire. By Professor J. W. Carr, M.A., etc. Nottingham: J. H. Bell, Ltd. 1916.

This compact and well-got-up volume is published for the Nottingham Naturalists' Society, which completed its fiftieth year in 1902, and testifies both to a superabundance of vitality in an association which can at this time issue a local faunal list running into six hundred pages, and to plenty of energy on the part of its compiler, who is Professor of Biology in Nottingham University College.

The lists of Invertebrates contained in it are the outcome of a Jubilee Fund raised by the Society in 1902, and of vigorous systematic field work taken up with this object. "It does not pretend," says Professor Carr, "to be more than a contribution towards the fuller knowledge of the Invertebrate animals of the county, but it will at any rate be of use in showing what has been accomplished and what remains to be done," and he hopes that its publication will stimulate others to take up the study of the Nottinghamshire local fauna. Great care has been taken to have the specimens concerned named by special authorities on the several groups, and the notes as to first occurrence, abundance, or otherwise, under the various species are, or may be in the future, sometimes of more than local interest. It is interesting, for instance, though rather depressing, to read under the heading of *Aphantopus hyperanthus* (the Ringlet) that it, like many other butterflies, has disappeared from districts in the county where it was formerly common.

The Emu, vol. xv, Nos. 2 and 3, October, 1915, and January, 1916. Melbourne: Walker, May & Co.; European Agents, Witherby & Co., London. 4*s*. each.

We have pleasure in welcoming these, the first numbers of the 'Australian Ornithologists' Union's Quarterly' which have reached us for review, and find considerable interest in some of the papers, such as Mr. A. H. Chisholm's notes on the Yellow-bellied Shrike-Tit (*Falcunculus frontatus*), which is illustrated by photos of the nest, a very deep cup built among twigs, made chiefly of the inner bark of eucalyptus. This is a quite unusual sort of nest to anyone used to our Tits; but tearing at bark is all in the day's work for this bird, whose remarkably powerful and shrike-like bill is used largely for hammering and tearing at bark, not for aggression on other birds; indeed, it seems the introduced Sparrows follow these Tits—which are much larger than our Great Tit—and dash in to steal some of the results of their work. The curious name of Yellow-hammer has been given to these birds, just as it has been in America to a Woodpecker, the Flicker (*Colaptes auratus*), for both birds hammer, and show yellow in their plumage, and the colonists had evidently forgotten all about our Yellow-hammer but the name. An interesting little note by Mr. Le Souëf follows this and relates another aggression by introduced birds upon natives, in which a pair of the well-known "Laughing Jackass" (*Dacelo gigas*) were evicted from a nesting-box, which they had already used at least once, by Starlings. But in this case "the return of the native" was in the nature of reprisals, for the big Kingfishers ultimately came back and ate up the young Starlings—why they did not thus treat the old birds is a puzzle. Over twenty-eight pages and several plates in this part are devoted to a paper by Dr. J. R. W. Shufeldt, of Washington, on the comparative osteology of Harris's Cormorant (*Nannopterum harrisi*)—an interesting species, because flightless and of recent discovery, but as it comes from the Galapagos, the paper seems rather out of place in a journal meant to "popularise the study and protection of native [Australian] birds." A note on the singular little quail-like Plain-wanderer (*Pedionomus torquatus*), the only four-toed Hemipode, indicates that this, like some of the true Quails, is apparently partly nocturnal, and is illustrated by a fine photograph of this species, now, alas! declining, in a characteristic tip-toe attitude. On the next page a very clear and beautiful print illustrates the tameness of one of four Laughing Jackasses, which have formed a habit of coming to the doorsteps of some of the residents of Upper Fern-tree Gully, Victoria, to feed on raw meat placed for them there; it is the work of Messrs. Littlejohns and Lawrence. In the January number there are some nice studies of the nesting of the charming tiny Mistletoe-bird (*Dicæum hirundinaceum*), illustrating a paper by the same observers; this species, we may remark, can be seen alive at the Zoo at present. There are several other studies of nests of Australian birds, of which the best and most remarkable is that of the Lemon-breasted Flycatcher (*Micræca flavigaster*), a structure which "is about the circumference of a half-crown and the receptacle of a single egg"; it is noted by Mr. A. J. Campbell. On the last page the editors observe that "a recent criticism stated that 'The Emu' was neglecting popular ornithology and was becoming too technical. The editors are keenly alive to the necessity of developing popular interest in Australian birds, and have not lost sight of that plank in the Union's platform. All papers dealing with the popular side of ornithology that have reached the editors have been printed in full." No doubt the splendid support Australia and New Zealand are giving us in the war has caused a falling off in bionomical contributions owing to the absence of many who would otherwise have contributed notes, but it struck us too in reviewing these numbers that there is a good deal more about nomenclature published than any practical ornithologist can be expected to stand with equanimity, while previous volumes of 'The Emu' have appealed to us as veritable mines of observation, so that we are not astonished at the criticism referred to.

The Auk. Vol. xxxiii. No. 1, January, 1916. American Ornithologists' Union, Cambridge, Mass. 75 cents.

THOSE interested in the duck tribe and in bird problems in general will find the papers of Dr. C. M. Townsend and Mr. John C. Phillips, appearing in this number of the great American ornithological quarterly, of unusual interest. Dr. Townsend records his observations on the courtship of the Merganser, Mallard, Black Duck, Baldpate, Wood Duck, and Buffle-head. The Merganser dealt with is the Goosander (*Mergus americanus*), a local race of the Old World bird rather than a full species; that of the Mallard is of course well known to us. In describing it Dr. Townsend does not mention the up-jerk of the stern which follows as a rule the rear-up of the drake. In the courtship of the Black Duck (*Anas rubripes* *), a species in which both sexes are very like female Mallard, but much darker, the male often flies for short distances over the water, as indeed does the Mallard, but less frequently. The Baldpate, which is our rare visitor the American Wigeon, displays very similarly to our bird, but apparently has a softer note; its ordinary note, certainly, as we have observed in captives here, is softer and has more syllables than our Wigeon's. The Wood Duck (*Aex sponsa*), the bird known to us in domestication here as the Carolina Duck, is described as bobbing his head up and down in an abbreviated bow, and erecting his crest. As we have seen him display, the action is quite different, the crest being actually flattened down, while the head and tail are raised and kept so in a rather stiff manner. The Buffle-head, when courting, an action believed by Dr. Townsend to be here described for the first time, "spreads and cocks his tail, puffs out the feathers of his head and cheeks, extends his bill straight out in front close to the water, and every now and then throws it back with a bob in a sort of reversed bow." Mr. Phillips brings to notice a very remarkable record of migrating waterfowl, the capture of three species of American ducks in the Marshall Islands, north-east of New Guinea. These were the Pintail, Green-winged Teal (*Anas carolinensis* *), and

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* *Anas obscura* and *Nettion carolinense* of the British Museum Catalogue.

Canvas-back (*Nyroca vallisneria*). These birds never occur in Australasia or Polynesia, and yet large flights of duck are said to pass the Marshalls for days in autumn, going from north to south and dropping stragglers to rest, while they return north in May. The story is over ten years old, and a German one at that, published in the 'Ornithologischer Monatsbericht'; but as the Marshalls are now in our hands, we may expect ere long some evidence on the subject from our own fellow-countrymen.

EDITORIAL NOTES.

Odd Eyes in Man, etc.—Such differences in the colour of the two eyes in humanity as Miss Holloway records on p. 112 are rarely observed, but we can, curiously enough, record four cases in which we have seen this abnormality. In 1892 we saw a man, with dark hair and moustache, with one eye grey and the other brown; we did not note the variation again till recently, when within the last few years we have seen a fair man with the same peculiarity, and also a woman, the colour of whose hair we did not notice. The last case that has occurred to us is that of a little girl of eight we saw last year, whose hair was fair. In her, as in the others, one eye was brown, the other being blue. One "wall"—very pale blue—eye, in contrast to the normal brown, may be seen in Dogs, Horses, and Rabbits, and white Cats may have one eye blue and the other green. Considering the great variability in iris-colour in birds, it is rather curious to find odd eyes so rare among them; we have only noted one case, a red-and-white tame Pigeon, with one brown eye and one white or "pearl" one. In this case the two sides of the head were also marked differently, so that different views of the bird gave the impression of two quite different individuals; but we noted no asymmetry other than that of eye-colour in the human cases above referred to. We have never noticed any instances of odd-coloured eyes in reptiles, amphibians, or fishes.

BRITISH 31 MAR 16 MUSEUM